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(54) Underreamer with extendable cutting blades

(57) A downhole rotary cutting tool (10) comprises a tubular body (12) and a pair of pivotally mounted blades (14,15) movable between a retracted position as in figure 4 and an extended position as shown in figure 1. The upper cylindrical portion of the body (12) contains an annular blade actuating piston (16), normally biased in the blade retracted position by a spring (18). The piston (16) is movable in response to elevated fluid pressure within the body (12). The lower face of the piston (16) is attached to the upper ends of two dowels (20,21) which extend through the body (12) and contact a cam member (22) which is axially movable on a rectangular body portion (24) extending below the cylindrical portion (12). The cam (22) includes two axially extending fingers (26,27) for engaging cam surfaces of the respective blades (14,15). The blades (14,15) are biased in the retracted position by respective torsion springs (32) and can pivot around pin (28). Increased fluid pressure causes piston (16) to act against spring (18) which in turn causes the dowels (20,21) to move downwards and cam against the legs of the blades pushing the blades (14,15) into the extended position. The angular extension of the blades (14,15) can be controlled by the variation of the fluid pressure. Drilling fluid can be injected through ports above and below the blades serve to assist the cutting action and carry cuttings to the surface.

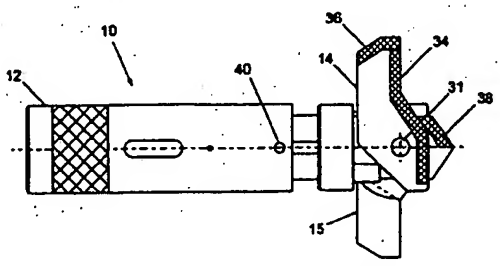

Fig. 1

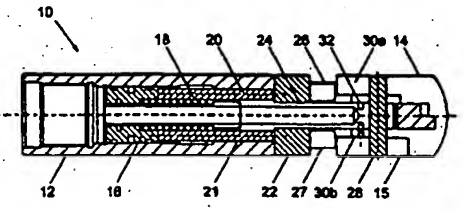

Fig. 4

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

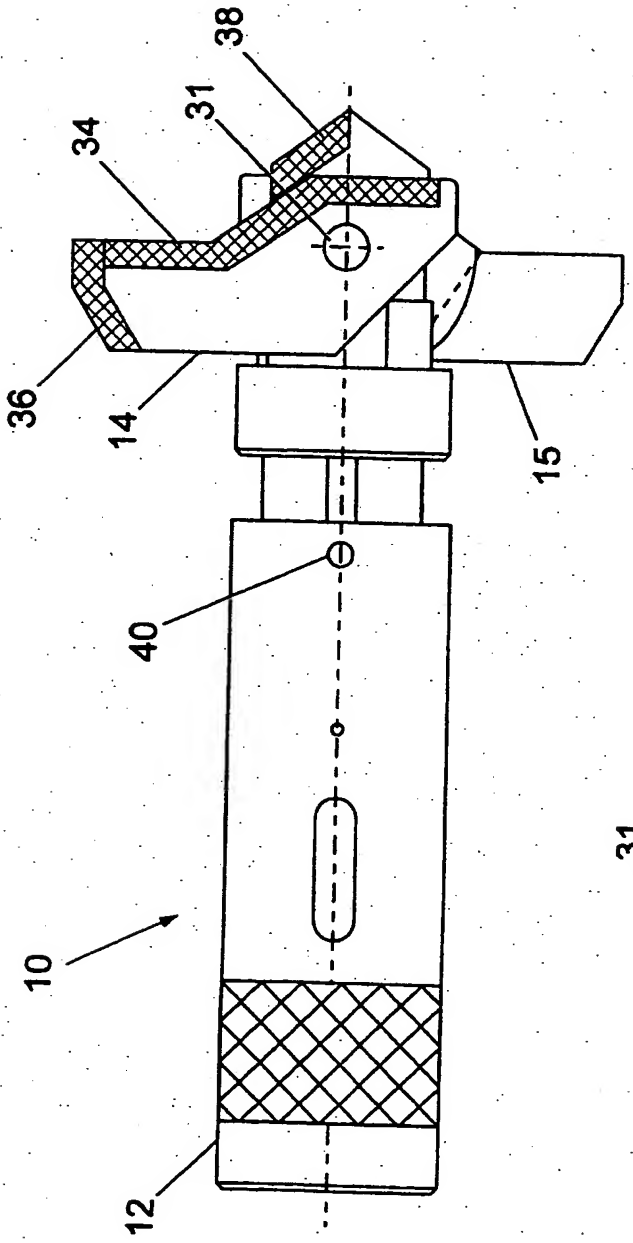

Fig. 1

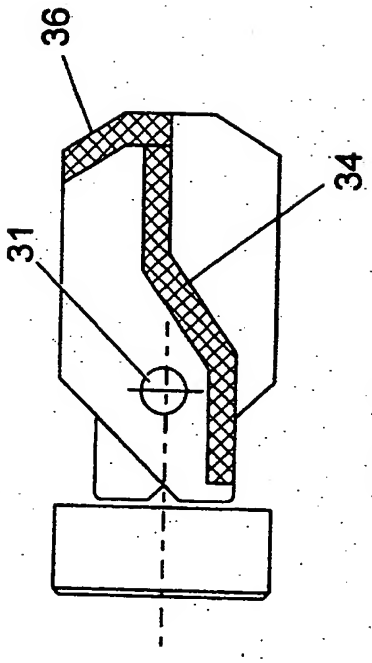

Fig. 2

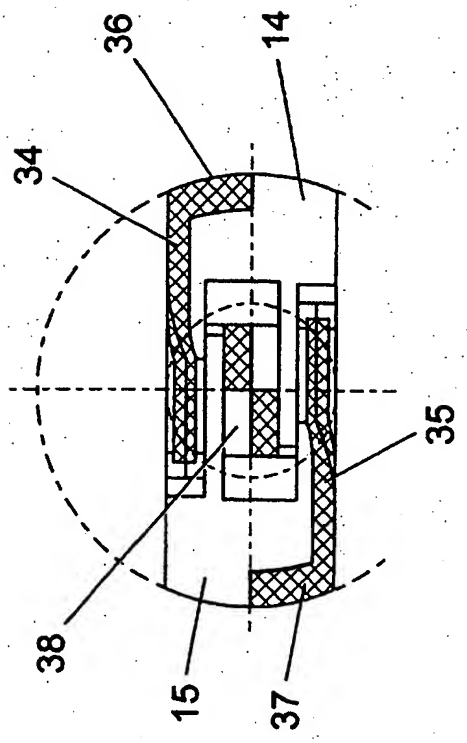

Fig. 3

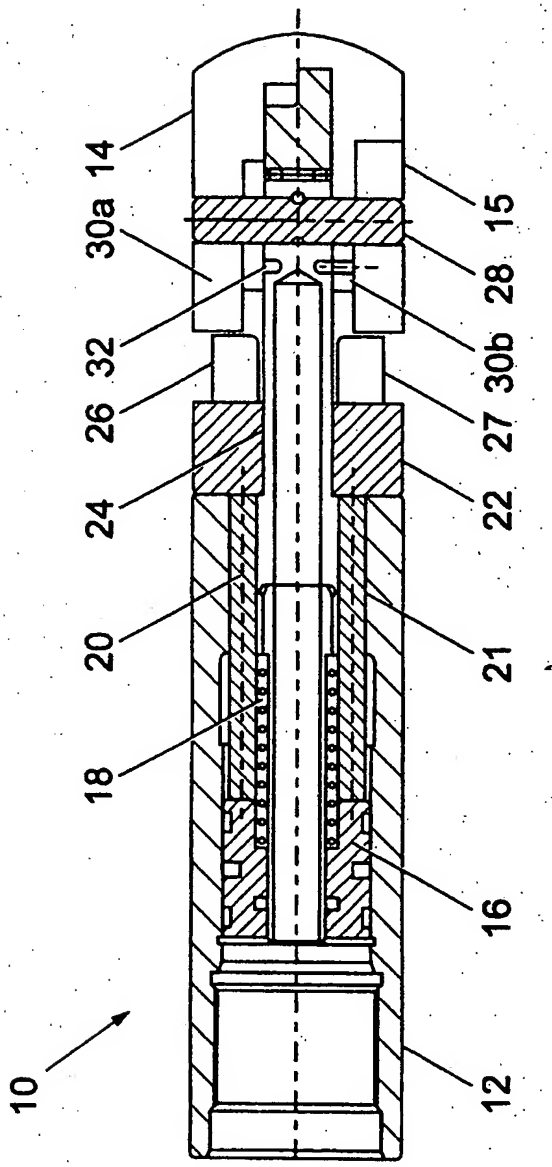

Fig. 4

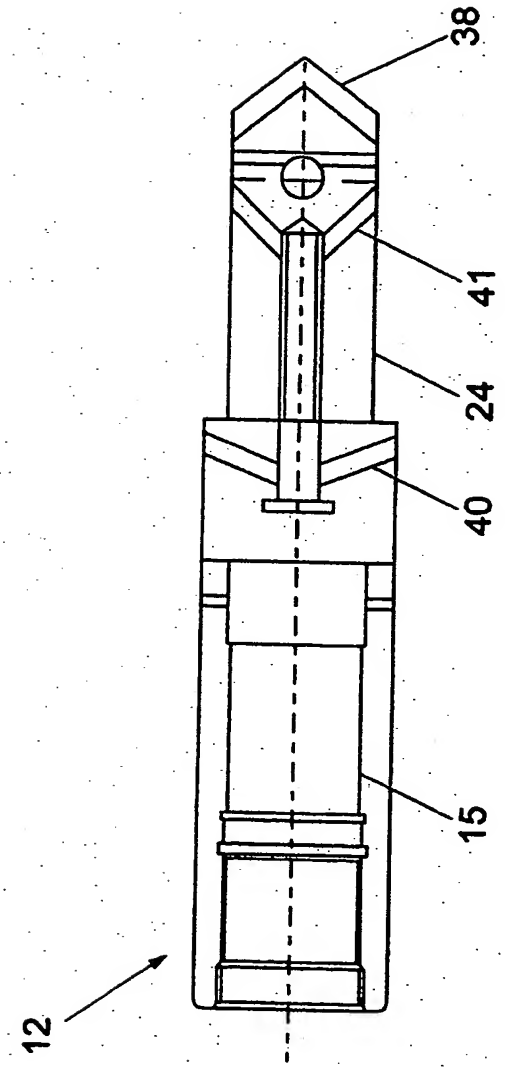

Fig. 5

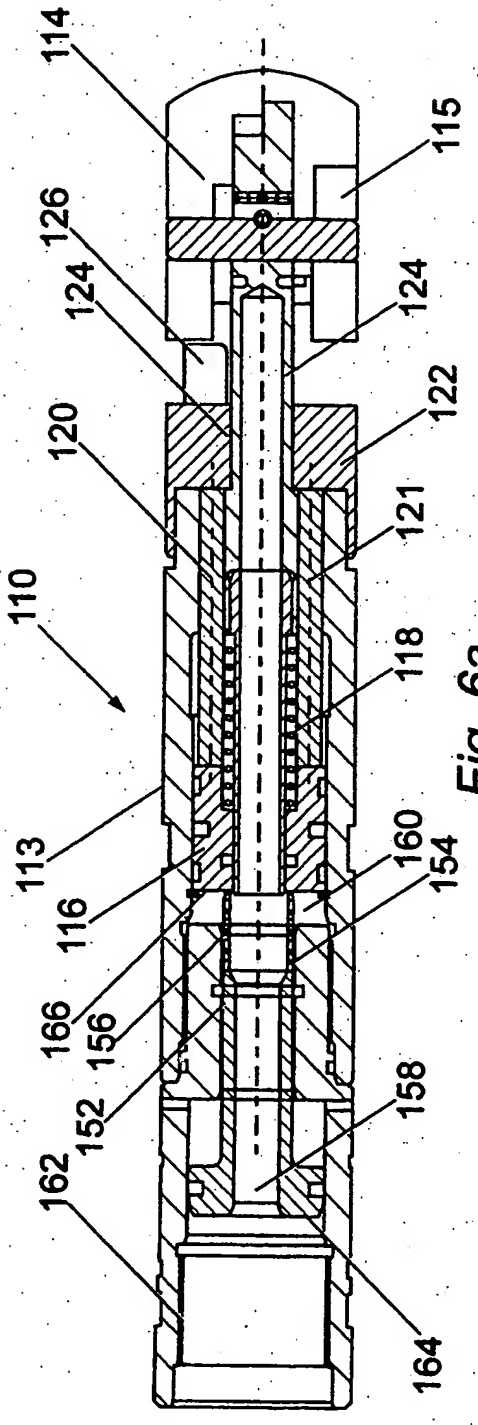
114
115
126
124
124
120
122
121
110
118
113
160
154
116
166
156
152
158
162
164

Fig. 6a

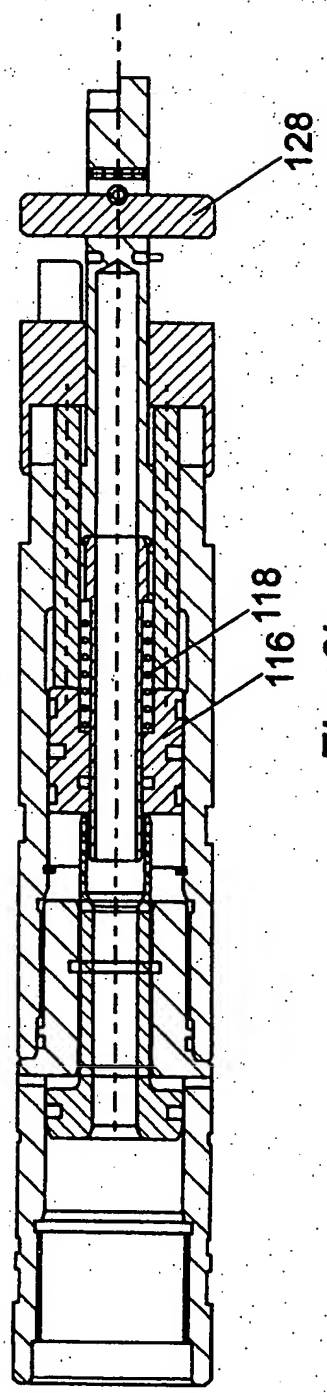
128
118
116

Fig. 6b

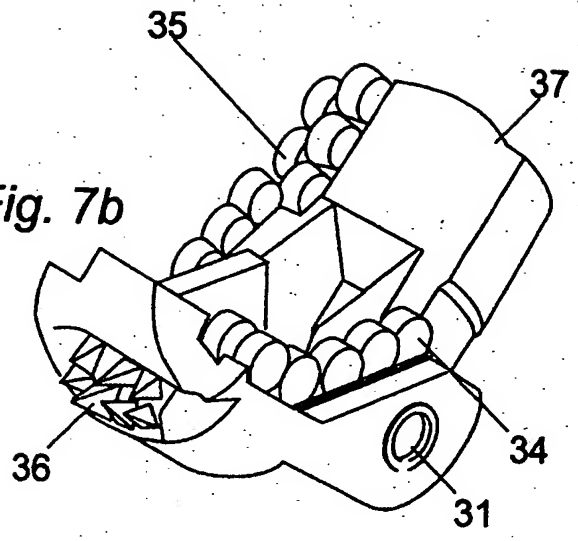

Fig. 7b

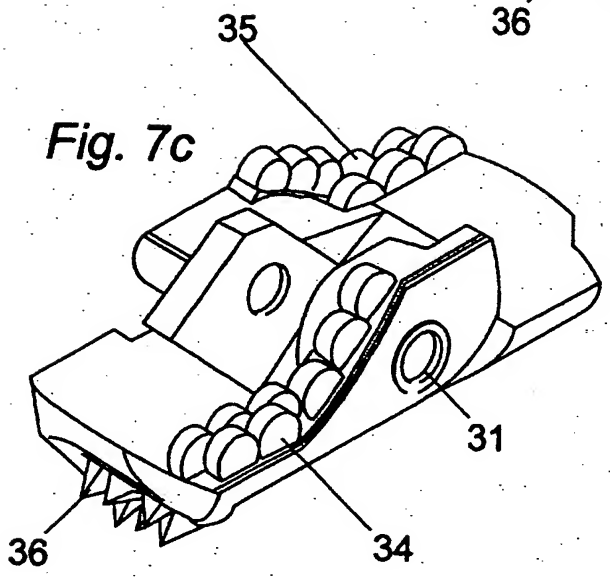

Fig. 7c

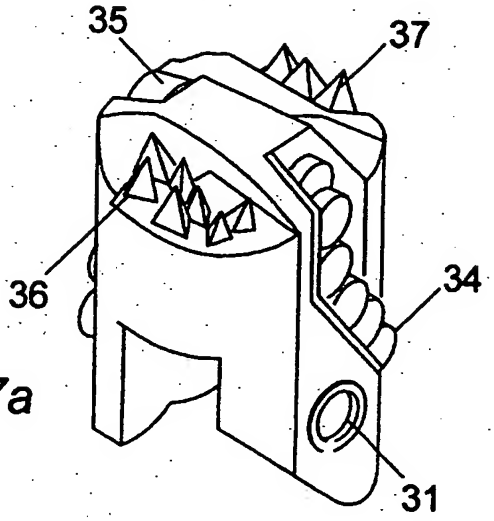

Fig. 7a

"Downhole Tool"

This invention relates to a downhole tool, and in particular to a downhole rotary cutting tool such as a section mill, underreamer or casting cutter.

When drilling or working on bores for use, for example, in oil or gas exploration or extraction, it is often desired to increase the diameter of a section of bore, which section of bore may be cased or uncased. This operation may be necessary to allow a larger diameter section of casing to be suspended below a section of smaller diameter casing or to cut casing to allow suspension of liner from the casing. The cutting operation may be carried out using a rotary cutting tool, which tools are known as, for example, section mills, underreamers or casing cutters. In the interest of brevity, the term "underreamer" will be used herein and is intended to encompass any rotary downhole cutting tool, including section mills and casing cutters, as the context permits.

Conventionally, underreamers comprise a slotted body for location in a drill string, the slots accommodating at least one pair of cutting blades mounted on a common

pivot pin. In the retracted position the blades lie within the body circumference. A piston within the body is movable in response to the internal fluid or mud pressure and acts on the blades to pivot the blades outwardly. In the retracted position the cutting face of each blade is directed downwardly, such that when the blades are extended the cutting faces extend downwardly and beyond the body diameter. Thus, the lateral extent or cutting diameter of the cutting faces is limited by the body diameter.

It is among the objectives of embodiments of the present invention to provide a rotary downhole cutting tool which may define a cutting diameter which is independent of the tool body diameter.

According to a first aspect of the present invention there is provided a downhole rotary cutting tool comprising a body and at least one blade pivotally mounted thereon and movable between a retracted position and an extended position, in the retracted position the blade lying substantially within the circumference defined by the body and a cutting face of the blade extending longitudinally of the body, and in the extended position the blade extending laterally of the body, and blade extending means for rotating the blade, preferably through an angle of greater than 45°, from the retracted position to the extended position.

The tool may be in the form of a section mill, underreamer or casing cutter.

The ability to rotate the blade through an angle of greater than 45° permits the tool to define a relatively large cutting area as, unlike conventional cutting tools, the extent of the cutting face of the

blade is not limited by the diameter of the cutter body. Preferably, the blade extending means rotates the blade through an angle of at least 60°, and more preferably an angle of at least 75°. In one preferred embodiment the blade extending means is capable of rotating the blade through approximately 90°, such that the blade extends substantially perpendicularly to the body axis. With this range of movement available the cutting width provided by the blade is substantially independent of the body diameter; in the retracted position the only limitation is the length of blade that may be accommodated. Further, in a preferred embodiment the degree of rotation of the blade is such that the downward forces experienced by the blade during a cutting operation, in response to weight applied to the tool from above, tend to maintain the blade in the extended configuration. This effect may be achieved by rotating the blade such that the resultant of the blade forces is directed outwardly of the blade pivot. With this arrangement, there is no requirement to continue to apply a blade extending force to the tool once the blade has been extended, other than the application of weight to the tool.

Preferably also, the body defines a stop for supporting the extended blade. Typically, the stop will engage a rear or upper surface of the extended blade. The stop may bear a large proportion of the load applied to the blade and minimise the load that must be borne by the pivot. Most preferably, the stop and blade cooperate such that forces, including torsional forces, applied to the blade may be transferred directly to the body and are not all transferred to the body via the pivot. Preferably also, the blade is capable of cutting in positions between the retracted and fully extended positions; the tool may be located in a bore of a

diameter only slightly larger than the body and then rotated while the blade is extended such that the bore wall is cut to accommodate the extended blade which then defines a cutting face suitable for reaming and like operations.

Preferably also, the tool is adapted to be located on the end of a string and the blade is located at the end of the tool, such that there are no limitations placed on the blade length.

Preferably also, the end of the tool defines a drilling member, such as a spade point; this feature is useful for removing any blockages encountered in a bore during a milling or reaming operation. The drilling member may be exposed only once the blade has been extended. Alternatively, or in addition, in the extended position the blade defines a cutting face which extends across at least half of the diameter of the tool when the blade is extended.

Preferably also, the blade is biassed towards the retracted position.

Preferably also, the tool includes at least two blades. Most preferably, the blades are mounted on a common pivot axis and in the extended positions extend from opposite sides of the body.

Preferably also, in the extended position each blade end surface extends around at least a 30° segment of the circumference swept by the extended blades. Most preferably, each blade end extends around between 40° and 70° of the swept circumference, and in the preferred embodiments between 45° and 60°. Such areas are larger than those provided in conventional cutters

and serve to stabilise the tool in a bore more effectively.

Preferably also, the width of each blade corresponds to the body diameter. The blades are thus far more robust than conventional cutter blades which must be narrow enough to be accommodated in slots in the tool body when the blades are retracted.

Preferably also, each blade defines two transversely spaced bearing areas for engaging the pivot which locates the blades on the body. This arrangement reduces the stress and strain experienced by the pivot pin and the blade bearing areas.

The blade extending means may be fluid actuated, mechanically actuated, or actuated by a combination of fluid and mechanical forces. Most preferably, the blade extending means includes a piston movable in a cylinder defined by the body. The piston may be movable in response to pressure forces exerted by fluid pumped into the body from the surface. The piston and the cylinder may be annular, allowing provision of a central bore at least partially through the body, which bore may communicate with jets or nozzles for directing fluid towards the cutting face. The piston may be linked to a blade extending cam by longitudinally extending members. The blade extending means may include two or more pistons, to increase the level of actuating force available.

Preferably also, the body defines a fluid passage communicating with an outlet adjacent the blade, so that fluid may be passed through the body and exit the body as a jet to assist in the cutting operation. Outlets may be provided both above and below the

blades. In a preferred embodiment at least one fluid passage may be selectively closed or restricted by a member operatively associated with the blade extending means, which member opens the passage when the blade is moved to the extended position. The opening of the passage, and thus the positioning of the blade in the extended position, is detectable at the surface as a decrease in back pressure when pressurised fluid is applied to the tool through a supporting member, such as drill pipe or coil tubing.

Preferably also, the blade extending means is biassed towards the blade retracted position.

According to another aspect of the present invention there is provided a downhole rotary cutting tool comprising a body and at least one blade mounted thereon and movable between a retracted position and an extended position, the body defining a fluid passage communicating with an outlet adjacent the blade, so that fluid may be passed through the body and exit the body as a jet to assist in the cutting operation.

This aspect of the invention may be provided in combination with the first aspect of the invention as described above, and in combination with any of the preferred or alternative features of the first aspect as described above.

These and other aspects of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a side view of an underreamer in accordance with a preferred embodiment of the present invention, showing the blades of the underreamer in the

extended position;

Figure 2 shows the blades of the underreamer of Figure 1 in the retracted position;

Figure 3 is an end elevation showing the blades of the underreamer of Figure 1 in the extended position;

Figure 4 is a sectional view of the underreamer of Figure 1;

Figure 5 is a sectional view of the body of the underreamer of Figure 1;

Figure 6a is a sectional view of a second embodiment of an underreamer according to the present invention;

Figure 6b is a sectional view of the underreamer of Figure 6a, with the blades of the underreamer removed; and

Figures 7a to c show the cutting blades for use with either embodiment of the underreamer in varying degrees of extension from the retracted position to the fully extended position.

The drawings illustrate a downhole rotary cutting tool in the form of an underreamer 10 for location on the lower end of a string of drill pipe (not shown); the tool may serve as a casing cutter, section mill or underreamer, but will be referred to herein as an underreamer. The underreamer comprises a tubular body 12 carrying a pair of cutting blades 14, 15 on the lower end thereof. The blades 14, 15 are illustrated in the extended position in Figures 1 and 3, and in the retracted position in Figure 2.

An upper cylindrical portion of the body 12 contains an annular blade actuating piston 16 (Figure 4), normally biassed to a blade retracted position by a spring 18. The piston 16 is movable in response to elevated fluid pressure within the body 12. The lower face of the

piston is attached to the upper ends of two dowels 20, 21 which extend through the body 12 and contact a cam member 22 which is axially movable on a rectangular body portion 24 extending below the cylindrical portion 12. The cam 22 includes two axially extending fingers 26, 27 for engaging cam surfaces of the respective blades 14, 15.

The blades 14, 15 are held on the rectangular body portion by a common hinge pin 28. The blades 14, 15 are U-shaped and each blade has two transversely spaced legs 30a and 30b on either side of the rectangular body portion 24. The pin 28 passes through apertures 31 in the legs 30a, 30b so that the blades 14, 15 may pivot about the pin 28. The blades 14, 15 are biassed towards the retracted position by respective torsion springs 32.

As best seen in Figure 4, the width of each blade 14, 15, at least at the blade end, corresponds to the body diameter, representing around 48° of the circumference swept by the extended blades.

Referring now to Figures 7a to 7c there is shown three-dimensional views of the blades 14, 15. Figures 7a shows the blades 14, 15 in the retracted position, whereas Figure 7c shows them fully extended. It will be appreciated that the blades 14, 15 may be used in an intermediate position, such as that shown in Figure 7b.

Each blade 14, 15 defines a primary cutting face 34, 35 which extends laterally of the body when the blades 14, 15 are in the extended position, as best shown in Figure 7c. The faces 34, 35 are provided with a hardened facing of, for example, tungsten carbide and it will be noted that each cutting face 34, 35 extends

over more than half of the diameter of the circumference swept by the extended blades. From Figure 2 of the drawings it will be noted that the faces 34, 35 lie longitudinally relative to the body 12 when the blades are in the retracted position. Each blade also defines a cutting face 36, 37 on the blade end surface, which surfaces are provided with tungsten carbide facing.

The cutting faces 36, 37 allow the underreamer to be operated without the blades fully extended. The projection of the faces 36, 37 allows the cutting faces to contact the inner bore and will abrade the surface of such as the drill string is rotated. Continued abrasion of the inner surface of the bore will allow the blades 14, 15 to reach their fully extended position.

In addition to the cutting face as defined by the blades 14, 15, the end of the rectangular body portion 24 also defines a spade point 38 provided with tungsten carbide facing.

The cutting action of the various faces is assisted by the action of jets above and below the blades formed by fluid pumped from the surface through the body 12 and out of appropriate jetting ports 40, 41 (Figure 5) in the body 12, the fluid also serving to carry cuttings from the cutting face to the surface.

In use, the underreamer 10 is mounted on the end of a length of drill pipe and run into a bore. At an appropriate depth, the drill string is rotated (in an anti-clockwise direction as viewed in Figure 3). Initially, the provision of the various springs 18, 32 ensures that the blades 14, 15 remain in the retracted

position. However, even in this position, the cutting faces 36, 37 may be used for drilling a relatively small diameter circular area. Drilling fluid or "mud" is then pumped through the drill pipe from the surface, and the pressure differential between the interior of the body 12 and the bore annulus pushes the piston 16 downwardly against the action of the spring 18. This movement pushes the dowels 20, 21 out of the cylindrical portion of the body and moves the cam member 22 into contact with the cam faces of the blades 14, 15. The blades 14, 15 are thus pivoted outwardly, and if necessary the cutting faces 36, 37 are employed to cut the bore wall to allow the blades to move to their fully extended positions. The provision of the cam fingers 26, 27 extending beyond the body of the cam member 22 and engaging the blade cam surfaces permits the blades 14, 15 to be rotated through 90°, until they are substantially perpendicular to the body axis. On reaching the fully extended positions the head of each blade comes into contact with a side face of the rectangular body portion 24 and thus acts as a stop, and also reduces the cutting force load that must be borne by the hinge pin 28.

The illustrated blade configuration is primarily intended for reaming in a downward direction, though the provision of cutting faces 36, 37 which extend onto the upper surfaces of the extended blades allows the underreamer 10 to be used to cut in an upward direction if necessary.

It will be evident that the cutting faces 34, 35 define a relatively large area, thus increasing the cutting rate and decreasing blade wear. Also, the relatively wide blades 14, 15 serve to stabilise the underreamer 10 in the bore, and of course provide blades which are

relatively robust and less likely to be damaged during reaming by normal drilling operations.

It will also be apparent that the extended blade configuration, that is the extended blades being over centre, leads to the forces experienced by the blades tending to maintain the blades in the extended position, unlike conventional pivoting blade cutters in which the forces experienced by the blades tend to force the blades towards the retracted position. Further, as the forces experienced by the blades 14, 15 are transferred to the body 12 via the upper or rear surfaces of the blades, the arms of the U-shape and the hinge pin 28, and there are no significant forces required between the cam fingers 26, 27 and the blade surfaces to maintain the blades extended, key seating of the blade cam surfaces and the cam fingers 26, 27 is most unlikely.

The term "key seating" refers to the groove which may be formed by continued application of the cam surfaces to the cam fingers 26, 27. In conventional tools, in order to keep the blades of the tool extended whilst reaming, the cam fingers must abut against the blades at all times. As the pressure required to keep the blades extended can be fairly substantial during reaming operations, a key or groove is often formed in the blade surface due to the relative movement of the blade during such operations. This groove can prevent the blades extending, or retracting, as the cam fingers may become stuck in the groove.

However, in the present invention, once the cam fingers 26, 27 have extended the blades 14, 15, the force required to extend the blades can be removed. This is because the weight of the drillstring above the tool

10, 110, will keep the blades extended without any additional force due to the inherent design of the tool 10, 110. In this way, the possibility of creating such a groove is substantially reduced.

It will be evident to those of skill in the art that the above-described embodiments offer numerous advantages over conventional cutting tools. It will further be evident to those of skill in art that the above-described embodiments are merely exemplary of the present invention, and that various modifications and improvements may be made thereto without departing form the scope of the present invention. In a further embodiment of the invention a skirt may be provided on the cam member 22 to cover the gap that is otherwise formed between the lower end of the cylindrical body portion 15 and the upper end of the cam member 22 as the blades are extended. The skirt prevents debris filling the gap which might prevent retraction of the cam member 22 and thus retraction of the blades. In the blade retraction position the skirt may cover the jetting points 40, these being exposed only when the blades are fully extended. The exposure of the ports 40, indicating that the blades are fully extended, will be detectable at the surface as a drop in fluid back pressure.

Referring now to Figs 6a and 6b, there is shown a second embodiment of underreamer, generally designated 110, according to the present invention. The underreamer 110 is substantially the same as the previous tool 10, except for the inclusion of an intensifier piston 152. Note that similar parts have been designated with the same reference numeral, prefixed by 1.

The purpose of the intensifier piston 152 is to increase the force applied to the piston 116. The intensifier piston 152 is positioned behind the piston 116, as shown in Fig 6a. Although only one such intensifier piston 152 is shown, it will be generally appreciated that any number of such pistons 152 may be cascaded in series to further increase the force applied to the piston 116.

Intensifier piston 152 has a plurality of apertures 154 therein at a front portion 156. The apertures 154 in the front portion 156 provide a fluid communication between the interior 158 of the secondary piston 152 and thus the bore of the tubing behind the tool 110, and an annular chamber 160 which is behind the piston 116.

In use, drilling fluid or mud is pumped down the central bore 162 of the tool 110 and the interior 158 of the secondary piston 152. The fluid pressure at the rear face of the intensifier piston 152 forces it downwards from the position shown in Fig. 6a against the piston 116 with which it engages. The downward movement of the piston 116 pushes down the dowels 120, 121 which forces the skirt 122 downwards against the blades 114, 115 as shown in Fig. 6b and forces them outwards, as in the previous embodiment.

In addition to providing the movement of the intensifier piston 152 acting directly against the piston 116, the drilling fluid pumped down the central bore 162 and though the interior 158 of the intensifier piston 152 passes both to the end of the tool and through apertures 154 into the annular chamber 160. The force of the fluid in the chamber 160 acts against the rear face 166 of the piston 116 and thus increases

the downward force on the piston 116. Hence, the intensifier piston 152 increases the surface area against which the force of the drilling fluid can act.

It will be appreciated that a number of such intensifier pistons 152 may be used in series, thereby increasing the surface area which is available proportionally and thus the force exerted on the piston 116 to extend the blades 114, 115.

This increase in force applied to the piston 116 results in an increase in the force, for the same pumping pressure, which is applied to the blades 114, 115 to keep them extended. This allows the tool 110 to back ream i.e. to cut while being retracted from a borehole. The increase in force applied to the blades 114, 115 keeps them extended even when a retracting force, such as that applied by the retraction of the tool 110, is applied to them.

The movement of the skirt 122 provides a means for reducing the back pressure in the system when the blades are fully extended. In Fig 6a, the skirt 122 is shown in the retracted position. However, in Fig. 6b the pressure applied by the drilling fluid has extended the dowels 120, 121 as previously described, which act against the skirt 122 forcing it downwards into the position as shown in Fig. 6b.

When the pressure of the fluid has fully extended the blades 114, 115, they tend to remain extended due to the downward force provided by the weight of the drill string above it. In this extended position, the skirt 122 uncovers a plurality of apertures (not shown) which extend through the rectangular body portion 124, to allow passage of the drilling fluid from the central

bore of the tool 110. Thus, the fluid pressure which was required to extend the blades 114, 115 is reduced upon movement of the skirt 122 to expose the apertures, thereby allowing the drilling fluid to escape into the borehole.

The venting of drilling fluid through the apertures reduces the back pressure in the system which is a substantial advantage of the present invention. When the tool 110 is driven by a hydraulic motor located further up the drill string, for example, any reduction in the back pressure at the motor allows it to operate more efficiently. In addition, the circulation of the drilling fluid out of the apertures helps to remove debris which collects in the borehole.

The inclusion of one or more intensifier pistons, as in the above described embodiment, offers a substantial advantage over conventional cutting tools. The intensifier piston increases the downward force applied to the blades by increasing the surface area against which the drilling fluid may act.

Furthermore, the provision of the skirt and apertures in the rectangular body allows the back pressure in the system to be substantially reduced when the blades are fully extended.

Modifications and improvements may be made to the foregoing without departing from the scope of the present invention.

CLAIMS:

1. A downhole tool comprising a body and at least one blade pivotally mounted thereon and movable between a retracted position and an extended position, in the retracted position the blade lying substantially within the circumference defined by the body and a cutting face of the blade extending longitudinally of the body, and in the extended position the blade extending laterally of the body, and blade extending means for rotating the blade from the retracted position to the extended position.

2. A downhole tool as claimed in claim 1, wherein the blade can be extended through an angle of 45° or greater.

3. A downhole tool as claimed in claim 1 or claim 2, wherein the blade is orientated downwards in use.

4. A downhole tool as claimed in any preceding claim, wherein the degree of rotation of the blade is such that the downward forces acting on the blade during a cutting operation tend to maintain the blade in the extended configuration.

5. A downhole tool as claimed in any preceding claim, wherein the blade extending means can rotate the blade through an angle of at least 60°.

6. A downhole tool as claimed in either preceding claim, wherein the blade extending means can rotate the blade through an angle of at least 75°.

7. A downhole tool as claimed in any preceding claim wherein the blade extending means is capable of

rotating the blade through approximately 90°.

8. A downhole tool as claimed in any preceding claim, wherein, the body has a stop for supporting the extended blade.

9. A downhole tool as claimed in claim 8, wherein the stop and blade cooperate such that forces applied to the blade are transferred to the body through the stop.

10. A downhole tool as claimed in any preceding claim, wherein the blade is capable of cutting in positions between the retracted and fully extended positions.

11. A downhole tool as claimed in any preceding claim, wherein the tool is adapted to be located on the end of a string.

12. A downhole tool as claimed in any preceding claim, wherein the blade is located at the end of the tool, such that there are no limitations placed on the blade length.

13. A downhole tool as claimed in any preceding claim, wherein the end of the tool has a drilling or cutting member.

14. A downhole tool as claimed in claim 13, wherein the drilling or cutting member is a spade point.

15. A downhole tool as claimed in either one of claims 13 or 14, wherein the drilling or cutting member is exposed only once the blade has been extended.

16. A downhole tool as claimed in any preceding claim,

wherein in the extended position the blade has a cutting face which extends across at least half of the diameter of the tool when the blade is extended.

17. A downhole tool as claimed in any preceding claim, wherein the blade is biassed towards the retracted position.

18. A downhole tool as claimed in any preceding claim wherein the tool includes at least two blades.

19. A downhole tool as claimed in claim 18, wherein the blades are mounted on a common pivot axis and in the extended positions extend from opposite sides of the body.

20. A downhole tool as claimed in either of claims 18 or 19, wherein in the extended position each blade end surface extends around at least a 30° segment of the circumference swept by the extended blades.

21. A downhole tool as claimed in any one of claims 18 to 20, wherein each blade end extends around between 40° and 70° of the swept circumference.

22. A downhole tool as claimed in any one of claims 18 to 21 wherein each blade end extends around between 45° and 60°.

23. A downhole tool as claimed in any preceding claim wherein the width of the or each blade corresponds to the body diameter.

24. A downhole tool as claimed in any one of claims 15 to 23, wherein each blade has two transversely spaced bearing areas for engaging the pivot which locates the

blades on the body.

25. A downhole tool as claimed in any preceding claim, wherein the blade extending means is fluid-actuated.

26. A downhole tool as claimed in any one of claims 1 to 24, wherein the blade extending means is mechanically-actuated.

27. A downhole tool as claimed in any one of claims 1 to 24, wherein the blade extending means is actuated by a combination of fluid and mechanical forces.

28. A downhole tool as claimed in any preceding claim, wherein the blade extending means includes a piston movable in a cylinder defined by the body.

29. A downhole tool as claimed in claim 28, wherein the piston is movable in response to forces exerted by fluid pumped into the body from the surface.

30. A downhole tool as claimed in claim 28 or claim 29, wherein the piston and the cylinder are annular, allowing provision of a central bore at least partially through the body, which bore may communicate with jets or nozzles for directing fluid towards the cutting face.

31. A downhole tool as claimed in any preceding claim, wherein the blade has a blade extending cam on which the blade extending means acts.

32. A downhole cutting tool as claimed in claim 31, wherein the piston is linked to the blade extending cam by longitudinally extending members.

33. A downhole tool as claimed in any preceding claim wherein the blade extending means includes two or more pistons, to increase the level of actuating force available.

34. A downhole tool as claimed in any preceding claim, wherein the body defines a fluid passage communicating with an outlet adjacent the blade, so that fluid may be passed through the body and exit the body as a jet to assist in the cutting operation.

35. A downhole tool as claimed in claim 30 or 34, wherein the outlets are provided both above and below the blades.

36. A downhole tool as claimed in claim 34 or 35, wherein at least one fluid passage is opened, closed or restricted when the blade is moved to the extended position.

37. A downhole tool as claimed in claim 36, wherein the opening of the passage, and thus the positioning of the blade in the extended position, is detectable at the surface as a decrease in back pressure when pressurised fluid is applied to the tool.

38. A downhole tool as claimed in any preceding claim wherein the tool is an underreamer.

39. A downhole tool comprising a body and at least one blade mounted thereon and movable between a retracted position and an extended position, the body defining a fluid passage communicating with an outlet adjacent the blade, so that fluid may be passed through the body and exit the body as a jet to assist in the cutting operation.

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Application No: GB 9725821.4 **Examiner:** Robert Fender
Claims searched: 1-38 **Date of search:** 8 April 1998

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Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): E1F: FCJ, FLA

Int Cl (Ed.6): E21B 7/28, 29/00

Other: -

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 2262758 A	(HAILEY) in particular figures 2 & 3 and page 5 lines 28-37	1-11, 13, 15, 17-23, 25-31, 33, 34, 38
X	GB 2245626 A	(HAILEY) in particular figures 2 & 3 and page 5 lines 28-37	1-11, 13, 15, 17-23, 25-31, 33, 34, 38
X	GB2211221 A	(HAILEY) in particular figures 4 & 5	1-11, 13, 15, 17-23, 25-31, 33, 34, 38
X	GB 2172315 A	(LUEN) in particular figure 1	1, 2, 4-7, 10, 11, 15, 17-19, 26, 38
X	GB 1596308	(WEAVER AND HURT LIMITED) in particular figures 1-3	1, 2, 4, 10, 11, 13, 15-19, 38
X	US 4938291	(LYNDE AND PRICE) in particular figures 1 & 2	1, 2, 4, 10, 11, 17-19, 38

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Category	Identity of document and relevant passage	Relevant to claims

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